Challenges in Implementing AI Technology Smart Farming in Agricultural Sector – A Literature Review

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ABSTRACT

Background/Purpose: *The agriculture sector is the backbone of every nation which contributes to the global economy. The implementation of technology in agriculture has brought revolutionary development in its outcome. Due to this, a drastic improvement in the global economy from the agricultural sector is expected. Moreover, the implementation of artificial intelligence (AI) improves the productivity of farmers giving solutions to various challenges faced by the farmers. The various AI tools that are developed for the agriculture sector include precision farming, predictive analytics, automated machinery, smart irrigation systems, crop and soil monitoring, supply chain optimization, weather forecasting, and livestock management. Adopting AI in agriculture faces several challenges despite its long-term benefits. The high upfront costs to be invested in implementing AI technology make it difficult for small-scale and developing farmers to invest in AI. Implementing the above technology needs technical skills, fast internet connectivity, and costlier equipment. Due to the lack of the above-mentioned requirements, the AI technologies that are meant for agriculture do not reach the farmers. This results in the wastage of resources for AI without the outcome. Considering the above issues an appropriate simplified model is proposed that facilitates the adaptation of the AI technology by small and medium-scale farmers in their agriculture to improve the performance.*

Objective: *The objective of this paper is to review the various journals related to the implementation of AI in Agriculture and to study the various issues related to its implementation. It also aims at identifying the research gap which will help to develop a model suitable for the end like small-scale and medium-scale farmers.*

Design/Methodology/Approach: *A systematic literature review was conducted by gathering and examining relevant literature from international and national journals, conferences, databases, and other resources accessed via Google Scholar and various search engines.*

Findings/Result: *The agriculture sector, crucial to every nation's economy, has seen revolutionary advancements through technology, especially AI. AI tools like precision farming, predictive analytics, and smart irrigation promise to enhance productivity and address various agricultural challenges. However, high implementation costs, resistance to new technologies, and lack of necessary infrastructure hinder widespread adoption among small-scale and developing farmers. To overcome these obstacles, a model is proposed to effectively support farmers in adopting AI technologies to boost agricultural performance.*

Originality/Value: *The implementation of AI and ML tools in agriculture from diverse sources is done. This area needs study due to recent challenges faced by small and medium-scale farmers in the implementation of AI and ML tools in agriculture. The information acquired will help to create a new model by improving the outcomes of the existing scenario.*

Paper Type: *Literature Review.*

Keywords: Artificial Intelligence (AI), Agriculture, Small-scale and medium-scale farmers, Precision Farming, Predictive Analysis, Automated Machinery, Supply Chain Optimization

1. INTRODUCTION :

The core of the Indian economy is agriculture. But from planting to harvesting, it encounters formidable obstacles. Therefore, modernizing agriculture is essential to addressing these issues. Artificial Intelligence (AI) is one of the main areas of computer science research, and because of its rapid technological advancement and wide range of applications, AI is quickly becoming relevant in the agricultural industry. In particular, AI is well suited to solve problems that humans are not very good at solving. AI-powered farming solutions improve crop quality and productivity by allowing farmers to accomplish more with less. The modern agricultural industry may see a direct use of artificial intelligence (AI) or machine intelligence as the pinnacle of a shift in traditional farming methods [1]. Several agricultural domains are used for the improvement of their performance as shown in Fig. 1. Numerous applications in the agricultural domain have been identified which is shown in Table 1. AI-powered agriculture is analyzed to improve efficiency by analyzing, acquiring, and responding to various situations. Several agricultural industries are using artificial intelligence technology to increase output and efficiency. AI in agriculture is assisting farmers in increasing farming productivity and minimizing adverse environmental effects. The agricultural sector embraced AI in a big and transparent way to improve overall results. AI technology is being incorporated into agriculture to help control and manage any unforeseen natural conditions.

Fig. 1: Agricultural Domains
Source: Oliveira, R. C. D. et. al. (2023) [2]

Table 1: Applications in the agriculture domains

Application Domain	Description
Crop management	Covers seed sowing, maintenance, harvesting, storage, and distribution.
Water management	Optimizing water usage through irrigation techniques and processes.
Soil management	Assuring plant nutritional sufficiency.
Fertirrigation	Technology that aims at the application of fertilizers via irrigation water.
Crop prediction	Crop production prediction is fundamental for the producer's logistic planning.
Crop classification	Crop classification aims to offer a global understanding of crop distribution and information for another application domain.
Disease and pest management	Affect crop yields and quality and reduces resource use efficiency. The wide variety of weeds, animals, and microorganisms that threaten agricultural crops requires technology for their protection.

Source: Oliveira, R. C. D. et. al. (2023) [2]

The application of computers in agriculture was first reported in 1983. Different approaches have been suggested to solve the existing problems in agriculture starting from the database to decision support systems. Out of these solutions, systems that apply AI are the most excellent performers as far as accuracy and robustness are concerned. AI is one of the key areas of research in computer science. With its rapid technological advancement and vast area of application, AI is becoming pervasive very rapidly because of its robust applicability in problems particularly those that cannot be solved well by humans as well as traditional computing structures. Agriculture is a dynamic domain where situations cannot be generalized to suggest a common solution. AI techniques have enabled us to capture the complex details of each situation and provide a solution that is best fit for that particular problem. Gradually very complex problems are being solved with the development of various AI techniques [3].

Artificial Intelligence (AI) in agriculture can lead to several technological developments. This includes the usage of cameras and other sensors, data analytics, the Internet of Things, and consultancy services. AI in agriculture will advance to the point where it can analyze a variety of data sources, including temperature, crop performance, weather, and soil, to generate more accurate forecast predictions. AI has the potential to enhance crop management and productivity in agriculture through the prompt identification of plant diseases and the effective application of agrochemicals. Quick plant phenotyping, agricultural monitoring, analyzing soil composition, predicting the weather, and yield prediction are all made easier using machine learning. An increasing number of farmers are utilizing AI, IoT, and other technological advances to increase the productivity of their land [4].

AI technology has immense contributions to agriculture. Precision farming, predictive analytics, automated machinery, smart irrigation systems, crop and soil monitoring, supply chain optimization, weather forecasting, and livestock management are the few AI technologies that can improve performance in agriculture.
AI in agriculture enhances efficiency by optimizing processes like crop management, irrigation, and harvesting, leading to higher yields. It enables precision farming through real-time monitoring of crops, soil, and weather, helping farmers make data-driven decisions to reduce waste. AI-powered drones and sensors monitor crop health and detect diseases early, allowing timely interventions and reducing losses. Predictive analytics use historical data and environmental factors to forecast yields, market demand, and optimal planting times, aiding in effective planning. Additionally, AI-driven automation reduces the need for manual labour in tasks like weeding, planting, and harvesting, resulting in cost savings for farmers [5].

Farmers face multiple challenges when adopting AI technologies, including high initial costs, which can be prohibitive for small-scale and resource-constrained farmers. Limited access to advanced technology and infrastructure, particularly in rural and developing areas, hampers adoption, while a lack of technical expertise necessitates substantial training and support. From a farmer's perspective, artificial intelligence is limited to the digital realm and may not be useful in the field. Incomprehension and exorbitant costs fall short of elucidating the benefits and appropriate application methods. Implements used in precision agriculture are limited in their use by small land holdings and uneven fields. Economic risks, such as potential failures and uncertain returns on investment, deter farmers from integrating AI. Additionally, AI solutions may not easily adapt to diverse agricultural conditions, such as varying climates, soil types, and crop varieties, complicating their implementation. Cultural and social resistance to change further hinders adoption, as traditional farming practices are deeply ingrained. Lastly, ensuring that AI technologies align with sustainable farming practices and do not negatively impact the environment presents a critical challenge.

2. OBJECTIVES OF REVIEW STUDY :

The objectives of our review study are:

(1) To study AI and its need in agriculture.
(2) To study the process of AI adoption in agriculture.
(3) To learn some agriculture techniques as being monitored by AI.
(4) To know the research gap and research agendas to contribute further research in the implementation of AI technology in agriculture.
(5) To design the schematic design architecture of the proposed system.

3. METHODOLOGY :

The study utilizes a systematic approach for conducting a historical literature review, which involves searching various resources from international and national journals, conferences, databases, and other sources on the internet to collect and analyze relevant information of the research study.

4. REVIEW OF LITERATURE ON RELATED WORKS :

The details of our literature study have been reported under five different categories of review based on the five different keywords.

4.1 Implementation of AI by Small-scale and medium-scale farmers in agriculture articles:

India's agricultural sector is central to its economy but struggles with traditional methods failing to meet food and employment demands. Implementing newer technologies like artificial intelligence (AI) is promising, enhancing farmers' income, productivity, and efficiency. This chapter discusses AI's role in advancing socioeconomic and environmental sustainability in Indian agriculture and highlights AI techniques adopted by small and medium-sized farmers [6].

Artificial Intelligence (AI) is revolutionizing agriculture by providing data-driven support to farmers and extension services, particularly benefiting smallholder farms in developing countries. AI enables precision farming through technologies like drones and sensors, improves crop surveillance, and offers timely recommendations via chatbots and virtual assistants. While AI faces challenges like high costs and resistance from farmers, successful initiatives like M-Velanmai and Plantix demonstrate its potential to enhance productivity and contribute to global food security [7].

Identifies several applications of artificial intelligence in agriculture, including irrigation, weeding, and spraying, using sensors and technologies embedded in robots and drones. These AI-driven solutions help conserve water, pesticides, and herbicides, maintain soil fertility, optimize manpower use, boost productivity, and improve crop quality [8].

This paper reviews the use of advanced technologies, including machine learning, IoT, and robotics, in precision farming, disease detection, and crop phenotyping to reduce chemical usage, cut costs, improve soil fertility, and increase productivity [9].

Farming is heavily influenced by unpredictable external factors like weather and pests, making initial planning challenging. AI systems require extensive data for training and accurate predictions, and while spatial data is easily obtained, temporal data is more difficult to collect. Additionally, in India, adopting AI in agriculture is costly and may increase unemployment [10].

The main objective is to review the various applications of artificial intelligence in farming. These developments reduce the excessive use of water, pesticides, and herbicides; they also aid in the efficient use of labor and enhance quality [11].

Apart from the above, the details of the study of other papers have been summarized in Table 2.

Table 2: Scholarly literature review on the Implementation of AI by Small-scale and medium-scale farmers in agriculture

S. No	Area and focus of Research	Outcome of Research	Reference
1.	The application of artificial intelligence (AI) in agriculture, including smart irrigation, harvesting robots, and weather forecasting, but limited adoption of AI tools among farmers of Karnataka.	The use of social media platforms and mobile applications can enhance AI awareness and improve agricultural activities, contributing to national economic growth	Patil, S. et. al. (2024). [12]

2.	Highlighted critical issues in agriculture, including lack of awareness of modern technology, financial challenges, and reliance on traditional methods and the aim is to enhance farmers' quality of life by reducing labor-intensive tasks through smart farming techniques.	Introduced "smart tillage," a platform for renting and leasing equipment, and developed a machine learning model using decision trees to aid in equipment hiring.	Rakhra. et. al. (2022). [13]
3.	Drones are used for field surveys, crop scouting, spraying, and surveillance.	Providing real-time data through sensors and cameras enhances decision-making and efficiency.	Pathak, H. et. al. (2020). [14]
4.	Developed a farm health monitoring system with Mobile phone's processing capabilities, integration with farm sensors, and internet access to alert farmers when crops need attention	It includes a cloud computing-based real-time agricultural monitoring and analysis system designed to help farmers manage their farms more effectively by reducing or eliminating the need for on-site consultations.	Junaid, M. et. al. (2021). [15]
5.	Addresses the increasing demand for food by proposing an intelligent method to predict and optimize crop yield using advanced machine learning models.	Aims to help farmers choose optimal climatic conditions for maximum productivity, with model performance evaluated using RMSE, MAE, median absolute error, and R-square values.	Shah, A. et. al. (2018). [16]

4.2 Articles on Precision Farming:

This review explores recent advancements in precision agriculture, focusing on IoT and big data utilization. It offers insights into innovations, challenges, and prospects, covering technologies like drones, sensors, and machine learning. Challenges discussed include data management, technology adoption, and cost-effectiveness [17].

The survey study provides an overview of precision farming, covering its fundamentals, methodologies, technologies, and applications. It explores the roles of global navigation satellite systems (GNSS), geographic information systems (GIS), remote sensing, and sensor technology in enabling precision agricultural methods [18].

Describes precision farming, or precision agriculture, as a modern technique that utilizes technology and data to enhance production, sustainability, and efficiency in agriculture. By integrating tools like GPS, GIS, remote sensing, variable rate technology (VRT), automated machinery, data management systems, mobile apps, weather monitoring, irrigation management, and crop management software, farmers can make informed, real-time decisions [19].

The abstract reviews the development of precision agriculture, focusing on techniques developed by the National Agriculture Research and Education System (NARES) to improve input resource use efficiencies. It discusses how modern tools and techniques enable precision farming in India, even among resource-poor small and marginal farmers, through skilled service providers. Adopting these practices enhances soil health, maintains water quality, and ensures environmental, food, and nutritional security [20].

The abstract states that precision farming technologies effectively enhance crop production and input use efficiency while reducing production costs and environmental impacts. However, it emphasizes the need to standardize low-cost, farmer-friendly tools and techniques for assessing soil and yield variability to optimize input application [21].

Farmers have historically employed imprecise conventional procedures, which have increased expenses and decreased production. Precision farming enhances productivity by accurately determining necessary practices, such as weather prediction, soil analysis, crop selection, and optimal use of fertilizers and pesticides. To gather data, comprehend systems, and forecast results, it makes use of cutting-edge technologies including machine learning, deep learning, IoT, and data analytics [22].

Precision farming leverages Artificial Intelligence (AI) and the Internet of Things (IoT) to revolutionize modern agricultural practices. These technologies have led to significant advancements in crop monitoring, resource management, and decision-making. However, challenges such as accessibility, connectivity, and integration complexity remain. The article emphasizes precision farming's role in enhancing agricultural productivity [23].

AI in smart agriculture can enhance farming, reduce costs, increase profits, and improve production management by enabling data collection and real-time assessments. While AI offers numerous benefits, its adoption faces significant challenges. This paper highlights the promise and challenges of AI in agriculture while outlining the subfields that require development and providing a clever framework for agricultural growth [24].

The study examines how artificial intelligence (AI) and the Internet of Things (IoT) might improve the sustainability and efficiency of contemporary agriculture by tackling issues like labor costs and climate change. It talks about resource management, crop yield forecasts, and precision farming applications, showing how these technologies increase real-time monitoring, automate processes, and improve decision-making. A more resilient agricultural future may be realized by examining the possibility of improved transparency and data security through the synergy between blockchain and cloud computing [25].

The study emphasizes the necessity of integrating AI into farming practices, particularly in production, irrigation, and harvest processes. AI-driven systems analyzing weather data, soil parameters, and historical yield data can optimize crop production, leading to increased profitability and sustainability in agriculture. Experimental outcomes demonstrate optimized irrigation, planting, and harvest functions, resulting in higher yields, reduced resource wastage, and improved profits. However, challenges of accessibility and cost hinder sector-wide adoption of AI in agriculture, yet ongoing research aims to address scalability and affordability through machine learning and sensor technology enhancements, promising further advancements [26].

Review of the literature performed on the keyword Precision Farming is listed in Table 3.

Table 3: Scholarly Literature on Precision Farming

S. No	Area and focus of Research	Outcome of Research	Reference
1.	Use of intelligent decision support systems (DSS) to improve agricultural suggestions and lessen environmental consequences.	Using latent profile analysis (LPA), was beneficial to improve engagement and potentially increase DSS adoption	Adereti, D. et. al. (2024). [27]
2.	Precision agriculture aims to enhance sustainability by applying treatments precisely in time and place, using automation and robotics.	Suggests improvements for developing efficient autonomous agricultural systems	Mahmud, M. S. A. et. al. (2020). [28]

3.	Various technologies in precision agriculture, including sensors, GPS, software, and remote sensing, can significantly highlight applications such as data collection, yield assessment, quality mapping, variable fertilizer dosing, and heat map development.	Boost crop productivity	Pandey, H. et. al. (2021). [29]
4.	AI technologies optimize crop cultivation through predictive modeling, precision agriculture, and efficient crop monitoring and disease identification.	Highlights how AI can transform food production, distribution, and management, fostering a more secure and sustainable future	Pandey, D. K. et. al. (2024). [30]
5.	AI-driven tools like robotics, drones, and IoT devices facilitate precision agriculture.	Enhance efficiency in crop and soil monitoring, weather forecasting, and supply chain management	Mahapatra, A. et. al. (2021). [31]
6.	Precision farming, utilizing IoT, data mining, analytics, and machine learning, enhances productivity by accurately predicting the weather, analyzing soil, and determining optimal crop and fertilizer use.	Helps economic development	Durai, S. K. S. et. al. (2022). [32]

4.3 Articles on Predictive Analytics:

Weather and climate significantly impact agricultural production, necessitating various crop and livestock monitoring activities using diverse methodologies. This study explores different crop monitoring systems, highlighting challenges in predictive analysis and remote monitoring. It emphasizes the crucial role of AI and machine learning in creating comprehensive frameworks for predictive analysis and intelligent greenhouse monitoring, involving data acquisition, processing, feature extraction, transmission, and classification [33].

This paper explores the transition from traditional to smart farming (Agriculture 4.0) driven by population growth and the need for efficient crop monitoring. It highlights the integration of robotics, including wheeled and aerial vehicles, with AI and IoT to enhance agricultural practices. The paper also discusses the use of image processing in AI to identify crop diseases and optimize herbicide use based on plant growth predictions [34].

The FAO predicts an additional 2 billion people by 2050, with only a 4% increase in cultivated land. To address this, AI can enhance farming by tracking and predicting agricultural parameters, improving crop yields, and optimizing resources. AI's applications include soil analysis, disease detection, and water management, already showing positive results in countries like Singapore and the US. Despite challenges like data requirements and initial investment, AI and IoT are crucial for sustainable agriculture and meeting future food demands [35].

The study explores agricultural automation to reduce farmers' physical labor and debt, highlighting the importance of tool renting and sharing for efficient resource management. A pilot study of 562 Indian farmers categorized them into small, moderate, and large groups, and applied three machine learning models—nearest neighbors, logistic regression, and decision trees—to analyze data on equipment needs. The decision tree model, reliant on various input factors, emerged as the most effective, suggesting significant social and economic benefits for farmers through improved access to necessary equipment [36].

Analyzes the integration of AI and ML in the agricultural supply chain (ASC), highlighting their impact on monitoring, prediction, and decision-making. It reviews applications in crop yield prediction, soil properties, irrigation, weather forecasting, disease detection, demand management, production planning, transportation, storage, inventory, and retailing. Popular technologies include artificial neural networks, support vector machines, UAVs, and remote sensors, with a focus on crop yield and soil properties prediction [37].

Surveys AI technologies that leverage data (e.g., temperature, precipitation, wind speed, solar radiation) and machine learning to predict weather, analyze crop sustainability, and evaluate farm health. It highlights the benefits of AI in providing personalized agricultural plans, understanding agricultural data, and addressing challenges like climate change and pest infestations to improve harvests [38].

Review indicates that adopting AI in the Agricultural Value Chain (AVC) can boost agricultural income, enhance competitiveness, and lower costs. Deep learning algorithms, particularly artificial neural networks, are widely used by AVC actors for water resource management, yield prediction, price and demand forecasting, energy efficiency, optimizing fertilizer and pesticide use, crop planning, personalized advisement, and predicting consumer behavior [39].

Review of the literature performed on the keyword Predictive Analytics is listed in Table 4.

Table 4: Scholarly Literature on Predictive Analytics

S. No	Area and focus of Research	Outcome of Research	Reference
1.	Developed a smartphone application for Android devices that leverages knowledge research techniques to enhance agricultural productivity.	The app predicts the most suitable crops based on current weather and soil conditions, detects leaf diseases, forecasts rainfall, and identifies soil nutrient deficiencies.	Mridha, K. et. al. (2021). [40]
2.	Predictive ML supervised classification algorithms, particularly K-Nearest Neighbor (KNN),	Assist in crop and fertilizer selection, pest control, and irrigation, considering factors like climate, soil type, and crop history	Sharma, R. et. al. (2024). [41]
3.	AI techniques help monitor crop health, detect weeds and plant diseases, and predict weather and commodity prices.	Benefits of AI in agriculture include optimized planting, irrigation, and fertilization, better resource management, enhanced food safety, real-time data analysis, and predictive maintenance.	Păvăloaia, V. D. et. al. (2023). [42])
4.	Use of machine learning with computer vision for classifying various crop images to monitor crop quality and assess yield	Focuses on predicting soil parameters like organic carbon and moisture content, crop yield prediction, disease and weed detection, and species identification.	Sharma, A. et. al. (2020). [43]
5.	Use of AI and machine learning in the food and agricultural sector	Helps in supply chain optimization, crop selection, logistics, disease detection, smart irrigation, yield prediction, and analysis of soil and weather data	Pallathadka, H. et. al. (2022). [44]

6.	Uses machine learning and deep learning techniques, including Decision Tree, Random Forest, XGBoost, CNN, and LSTM	To forecast crop yields in India, benefiting small-scale farmers.	Sharma, P. et. al. (2023). [45]

4.4 Articles on Automated Machinery:

This paper provides background on AI methods in agriculture, including machine learning, IoT, expert systems, image processing, and computer vision. It reviews the literature on effective AI applications in data collection, smart robots, and monitoring systems for crops and irrigation. The paper highlights how AI maintains quality, productivity, and sustainability, and discusses the benefits and challenges of various AI methodologies in smart farming [46].

This study reviews the role of AI and IoT in digitizing and automating agriculture, highlighting their significant impact on pre-and post-harvest operations. It emphasizes the importance of sensor-generated data, managed through machine learning, to predict farming challenges. Applications include smart machinery, irrigation, pest control, and more, with CNNs aiding in automation. While the security of local networks poses a challenge, the cost-effectiveness and robustness of IoT and AI solutions promise widespread adoption. The analysis aims to guide researchers and stakeholders in selecting optimal models and techniques for agricultural tasks [47].

This paper reviews AI's role in agriculture, highlighting its importance in improving crop yield and quality. It examines 77 studies from the past 21 years, showcasing various AI approaches in farming. The research aims to aid further exploration of AI techniques and their applications in agriculture [48].

Measuring the work area of agricultural machinery is vital for various operational and analytical purposes but is often hampered by manual methods' inaccuracy and time consumption. This study presents a smart system using IoT, GPS, and AI to automatically and precisely calculate the work area of agricultural machinery. The system employs nearest-neighbor algorithms and contact-based mechanisms, achieving accurate measurements with a maximum 9% error for irregularly shaped fields [49].

This study explores the integration of AI with drones in agriculture through a bibliometric analysis of 234 articles from Scopus and Web of Science. Findings highlight the transformative potential of AI-driven drones in crop monitoring, precision agriculture, and environmental sensing, offering insights and identifying knowledge gaps for future research and sustainable farming advancements [50].

This article explores the transformation of Indian agriculture through technological advancements, highlighting innovations such as precision farming, intelligent irrigation, and AI-powered crop monitoring. It discusses the role of data analytics, drones, and biotechnology in enhancing efficiency, sustainability, and productivity. The comprehensive analysis underscores the sector's promising future as it embraces these innovations to address food security and rural challenges [51].

Review of the literature performed on the keyword Automated Machinery is listed in Table 5.

Table 5: Scholarly Literature on Automated Machinery

S. No	Area and focus of Research	Outcome of Research	Reference
1.	Precision agriculture aims to optimize treatments with minimal input for high efficiency and sustainability, leveraging automation and robotics to reduce environmental impact while maximizing output.	Highlights the diverse challenges of different farming operations, emphasizing the need for tailored solutions and cost-effective development to ensure broad adoption by farmers.	Mahmud, M. S. A. et. al. (2020). [52]

2.	Reviews research and commercial agricultural robots used in crop field operations.	Highlighting the focus on harvesting and weeding robots, while noting less attention on disease detection and seeding robots.	Fountas, S. et. al. (2020). [53]
3.	Agricultural robots play a crucial role in modern digital agriculture, leveraging advancements in computer science, sensing, and control technologies.	Robots remain limited to small-scale applications due to insufficient artificial intelligence integration.	Cheng, C. et. al. (2023). [54]
4.	Remote sensing applications	Highlights recent advances in sensor applications in agriculture, featuring 14 articles on soil and plant sensing, farm management, and post-harvest applications.	Kayad, A. et. al. (2020). [55]

4.5 Articles on Supply Chain Optimization:

Recent AI advancements have created decision support systems for pest identification and monitoring in agriculture, yet these often fail to meet user demands, hindering integration into integrated pest management (IPM). Challenges include AI effectiveness, field functionality, computational expertise, and system mobility. Effective, adaptable, user-friendly, low-cost, and mobile AI systems can overcome these obstacles, supporting innovative IPM integration for farmers [56].

The COVID-19 pandemic has exacerbated challenges for Indian farmers, highlighting the potential role of artificial intelligence (AI) in agricultural advancement. This paper evaluates AI's application and benefits in agriculture amidst the crisis. Through survey data from 523 farmers and Interpretive Structural Modelling (ISM) and MICMAC analysis, key challenges for implementing AI are identified, including responsive time and accuracy, standardization issues, data requirements, costs, implementation methods, versatility, awareness gaps, and employment concerns [57].

Explains that artificial intelligence (AI) is enhancing farmers' efficiency and reducing environmental impacts in agriculture. The industry has embraced AI to transform outcomes by managing adverse natural conditions and detecting diseases or climate changes early. AI helps process agricultural data to mitigate negative impacts. In conclusion, AI is an emerging technology with significant potential to improve agriculture in India [58].

Developed a Smart Health System for Agricultural Machines with Deep Learning-based Optimization (SHMAM-DLO) using IoT and AI. It proposes a Fusion Genetic Algorithm (FGA) and Artificial Neural Network (ANN) for optimization in monitoring agricultural machine health. By utilizing smartphone microphones instead of costly IoT sensors, it enables cost-effective implementation [59].

AI in agriculture is enabling greater productivity with less labour, land, and time. It can promote intelligent agricultural methods to reduce farmer losses and increase their profits [60].

It reveals that AI-based farm advisory systems significantly help farmers make proactive decisions. AI is extensively used in developed countries, benefiting farmers, and its application in India through deep learning techniques aids in accurate crop yield assessments and production predictions. AI promotes effective resource management, technical learning, and genetic modifications in plants, efficient land-use management, and crop relocation activities [61].

Agriculture significantly contributes to India's economy, but population growth and climate change impact crop production and food security. This research utilizes machine learning to estimate crop yield for five crops in Rajasthan, India, finding Random Forest to be the most effective algorithm with an R^2 of 0.963. The results, validated using R^2, RMSE, and MAE, aim to help farmers improve crop yield through informed crop selection [62].

Review of the literature performed on the keyword Supply Chain Optimization is listed in Table 6.

Table 6: Scholarly Literature on Supply Chain Optimization

S. No	Area and focus of Research	Outcome of Research	Reference
1.	Examines the impact and applications of IoT, smart sensors, WSN, image processing, data analytics, AI, and ML technologies in modern agriculture.	Technologies aim to make agriculture smarter, easier, and more productive with minimal resources.	Shanmugasundaram, N. et. al. (2023, March). [63]
2.	AI and cognitive technologies enhance farm efficiency, improving crop yield, and soil health, producing essential dietary staples, and meeting the industry's needs	AI will enable farms of all sizes to operate efficiently and sustainably, ensuring global food security.	Malo, M. (2020). [64]
3.	Discuss advances in weather monitoring systems for sustainable smart agriculture.	Highlights the use of historical data, measurements, models, algorithms, and computations to enhance food production, safety, and security	Ukhurebor, K. E. et al. (2022). [65]
4.	In the agri-food sector, AI enhances productivity, efficiency, and sustainability through precision agriculture, crop monitoring, predictive analytics, supply chain optimization, food processing, quality control, personalized nutrition, and food safety.	Highlights AI's transformative impact on the agri-food sector by improving efficiency, reducing waste, and enhancing food safety and quality.	Taneja, A. et al. (2023). [66]

5. SUMMARY OF THE LITERATURE SURVEY :

The current research on the implementation of AI in agriculture has contributed many innovative contributions to agriculture. The various contributions of AI include smart sensors, drones, GPS (Global Positioning System), WSN (Wireless Sensor Network), GIS (Geographic Information System), software, Unmanned Aerial Vehicles – UAVs popularly known as drones and remote sensing satellites. The literature has also employed various AI and machine learning techniques, through which we came to know that AI approaches are assisting in raising production and overcoming obstacles such as crop yield prediction, soil properties, irrigation, weather forecasting, and disease detection which helps in maintaining quality, productivity, and sustainability of various AI methodologies in smart farming. However, it is observed that the implementation of the above technology in the agricultural sector has challenges as high-cost equipment cannot be affordable to small and medium-scale farmers, limited access to advanced technology and infrastructure, particularly in rural and developing areas, hampers adoption, while a lack of technical expertise necessitates substantial training and support. AI solutions may not easily adapt to diverse agricultural conditions, such as varying climates, soil types, and crop varieties, complicating their implementation. The final section of the review addresses the problems and difficulties associated with applying AI, particularly in agricultural sectors. Although this review may not cover every article published on the implementation of AI in agriculture, it provides valuable insights into current trends and obstacles in this area.

6. CURRENT STATUS AND NEW RELATED ISSUES :

The research conducted so far on the implementation of AI and ML tools in agriculture had greater hope for practical implementation. However, due to several reasons, these techniques have failed in reaching the agriculturists. The major drawbacks of such failure may include a lack of knowledge of

AI and ML tools by the agriculturists, tools supporting major activities of agriculture for large-scale, medium-scale as well as small-scale farmers. Many of the AI and ML tools are not customized as per the requirements of the agriculturists. This makes the agriculturists not to implement the above tools practically. It is very essential to customize the AI and ML tools for small-scale, medium-scale and large-scale farmers as per their needs. In this concern, various journals and articles are reviewed and the following issues are identified.

- Implementing AI technologies in agriculture requires significant investment in hardware, software, and training, which are not affordable for small-scale and medium-scale farmers in developing countries.
- Farmers often lack the technical skills needed to operate and maintain AI systems. There is often a shortage of training programs designed to educate farmers and agricultural professionals on how to use AI technologies as well as how to troubleshoot issues.
- Unpredictable changes in temperature, rainfall, and extreme weather events can disrupt farming operations, which can lead to harvesting too early or too late, impacting crop quality and market value. Accurate weather forecasts are essential for determining the best times to harvest crops.
- A lack of knowledge about soil properties, Crop yield prediction, Disease and weed detection, and drip irrigation can lead to ineffective soil management practices. Without proper knowledge, farmers might apply fertilizers incorrectly, which can harm the soil and crops.
- Many rural areas where farming is the main culture lack high-speed internet, which is essential for accessing cloud-based AI services, real-time data transfer, and communication between devices.

7. RESEARCH GAP :

Following research gaps are identified: -

(1) High-cost: mall-scale and medium-scale farmers cannot afford high-tech equipment due to their financial status.
(2) Information on AI tools: The adoption of new technology is hindered by limited knowledge of infrastructure and resources. This requires significant training and support.
(3) Uncertainty in weather forecast: Uncertainty in weather forecast is a major challenge in agriculture. To provide updated information about the weather forecast many AI and ML tools are available. But these tools fail to reach the end users who are nothing but the farmers.
(4) Poor knowledge of Soil Culture: Ineffective soil management techniques can result from a lack of understanding about soil qualities such as crop yield prediction, disease and weed identification, and drip irrigation.
(5) Need for robust infrastructure: Many rural areas lack in getting high-speed internet, which is essential for cloud-based AI services, and real-time data transfer.

8. RESEARCH AGENDA BASED ON THE RESEARCH GAP :

The primary goal of the research is to create a model that can provide low-cost, dependable solutions based on existing data and should assist farmers globally.
The proposed model with the name ‘Krishi-Culture App’ is planned to fulfill the research gap by giving facilities like cost management where the small-scale and medium-scale farmers can get the details of the necessary items including their availability and price. Here the app generates the necessities of the farmers as output by taking the input data from the farmer during the registration process. The data like personal details, land details, location details, and crop details fed during the registration process are used in several features of the app as inputs to generate the required dependable solutions.

The proposed model's block schematic representation is shown in Fig. 2.

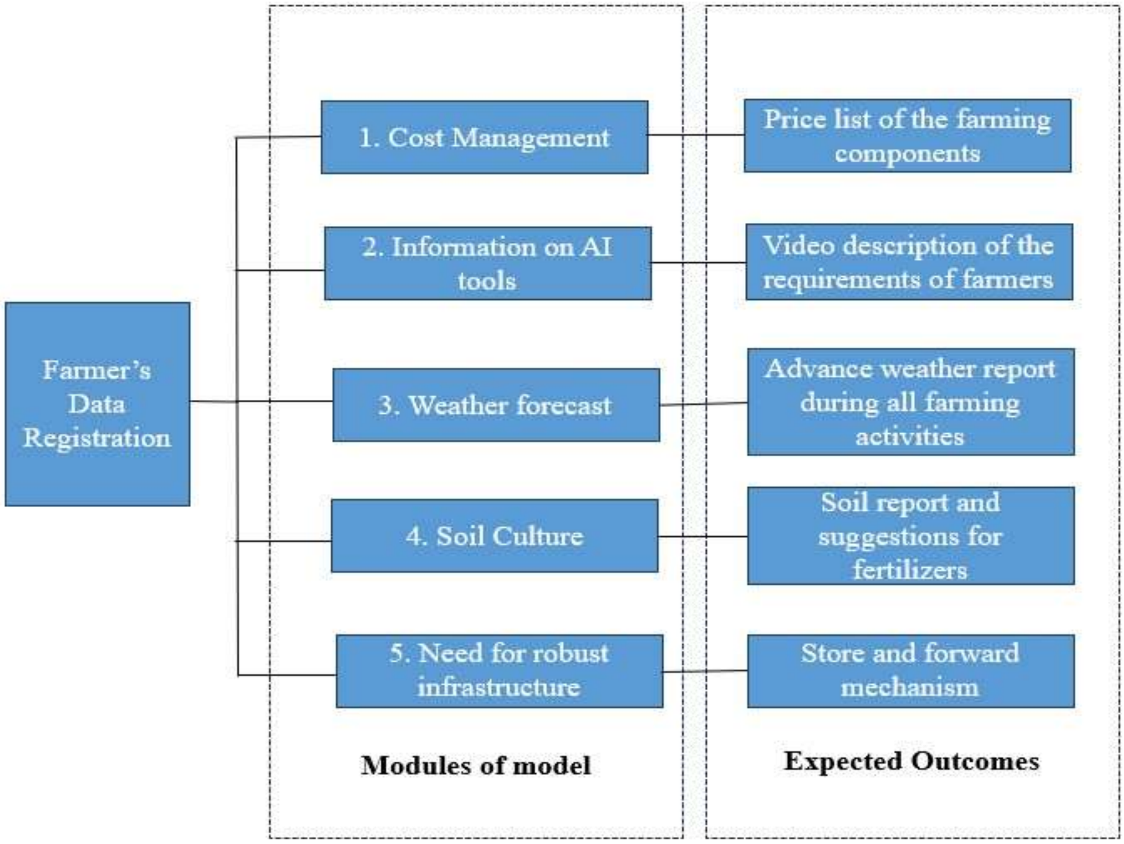

Fig. 2: Schematic representation of the proposed Krishi-Culture App Model

The following are the advantages of the proposed model.
- Avoids confusion and provides services in the most simplified form.
- Gives detailed information about the use of equipment, and other necessities by taking input data from the farmers.
- Farmers will get to know the weather conditions on request during the different activities of farming like harvesting, weeding, manuring, spraying, etc.
- Supports the soil culture of the farmer and suggests the necessary supplements to be added.
- Model uses the internal memory to store and forward the details based on internet connectivity. However, dynamic use of the model app needs fast internet connectivity which is a challenge in the rural area and may bring a limitation to the app.

The features of the proposed model are listed below.
(1) Cost Management:
This feature of the model is used to create a database with all the types of equipment, pesticides, and fertilizers that are part of agriculture. Based on land size and crop type, output will be displayed as per the needs of the farmers.
(2) Information on AI tools:
Gives information on farming activities in the form of YouTube videos as per the needs of the farmers.
(3) Weather forecast:
This feature of the model will consider a real-time weather report (.csv file) which is compared with the database containing the list of crops taken from the registration data to help the farmer predict the weather conditions for various activities related to farming. This will reduce the loss and improve the performance of the farmer's agriculture activities.
(4) Soil Culture:
This feature of the model will inform the various parameters of the soil and suggest the supplements to be given to improve productivity.

(5) Store & forward mechanism:
This feature of the model takes all the details from the farmer and stores them in the system whenever there is no internet connectivity. The moment the internet connectivity is available, forwarding of messages is done. This feature is helpful for the farmers to work even in places where there is no internet connectivity.

9. CONCLUSION :

AI and ML tools provide remarkable contributions to the agricultural sector. Many tools help the farmers find out the various reports like machinery, weather forecast, soil culture, etc. However, it is observed by referring to various journals, articles, and papers that these tools fail to reach the end users i.e. the farmers. Keeping this in mind certain research gaps are identified and a model is proposed which will use the AI and ML tools in such a way that the outcome of the model is understandable to the farmers. The model is mainly focused on small-scale and medium-scale farmers to provide information like material management, information, weather forecasts, soil culture, and network management. The overall objective is to educate and implement AI and ML tools in agriculture.

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